$1x10^{19}$ atoms/cm^3 or less and a ratio of a full band width at half maximum (FWHM) of a Raman peak of said channel semiconductor layer to a FWHM of a Raman peak of a single crystalline silicon is less than 3.

35. A thin film transistor comprising:

a channel semiconductor layer;

a gate insulating layer contacting said channel layer; and

a gate electrode adjacent to said channel layer with said gate insulating layer therebetween,

wherein said channel semiconductor layer comprises a non-single crystalline silicon semiconductor layer containing oxygen at a concentration $1x10^{19}$ atoms/cm^3 or less and a peak intensity ratio Ia/Ic of said channel semiconductor layer is less than 0.4 where Ia represents a Raman peak intensity at a wavenumber of 480 cm^{-1} for an amorphous component of said channel semiconductor layer and Ic represents a Raman peak intensity at 521 cm^{-1} for a single crystalline silicon.--

REMARKS

Reconsideration and allowance of this application are respectfully requested.

Referring to section 4 of the Office Action, the claims are rejected under 35 U.S.C. 102(b) or 35 U.S.C. 103 over Nakagawa. Nakagawa is directed to a polycrystalline semiconductor layer 101 containing predetermined ranges of carbon, sulfur, nitrogen or oxygen. The foregoing dopants are added as impurities in the ranges mentioned at column 3, lines 16-25. By intentionally

adding the foregoing elements, the semiconductor has "high reliability", see column 3, lines 27-30.

Moreover, by employing an average grain size of 200Å or more, carrier mobility can be improved, see column 4, lines 17-28.

With respect to the upper impurity level of 5 x 10 atoms/cm^3 recited in the claims of the subject application, it is urged in the Office Action that the 0.01-5 atomic% level of Nakagawa would correspond to the concentration range recited in the claims.

However, it should first be noted that dopants of Nakagawa are intentionally incorporated in the semiconductor while the purpose of the present invention is to maintain the concentration of unintentionally introduced impurities below 5 x 10^{19} atoms/cm^3. This distinction is helpful in understanding why the claims of the subject application are patentable over Nakagawa.

Inasmuch as 100 atomic% is about 5 x 10^{22} atoms/cm^3, the upper impurity limit of 5 x 10^{19} atoms/cm^3 recited in the claims of the subject application corresponds to an upper limit value of 0.1 atomic percent. Hence, there is a small overlap of the range recited in the claims and the range disclosed in Nakagawa. However, it can be seen that the 5 atomic% upper limit value of Nakagawa is substantially greater than the 0.1 atomic percent upper limit of the claims. Hence, it follows that in Nakagawa the amount of carbon, nitrogen or oxygen can be excessive and thus impede crystallization of the non-single crystalline layer during laser crystallization thereof whereby laser annealing alone will still result in low carrier mobility as described in the paragraph bridging pages 2 and 3 of the subject application and as discussed in the Amendment dated August 8, 1994 at page 6 thereof.

Hence, with respect to the impurity level concentration, applicant has selected an upper limit on the concentration thereof which will facilitate the formation of a layer which exhibits a Raman shift at a wavenumber of $512cm^{-1}$ or higher. By so selecting the upper limit on the carbon, nitrogen, and oxygen impurities, the claims distinguish over Nakagawa in this first respect even though there is a small overlap with respect to the range of dopants intentionally added by Nakagawa.

With respect to the foregoing, the rejection may be characterized as an "obvious-to-try" rejection. That is, it is effectively contended it would be obvious to try an impurity concentration range of 5×10^{19} atoms/cm^3 (0.1 atomic %) or less even though the dopant of Nakagawa is intentionally introduced because the Nakagawa dopant concentration range includes part of the impurity concentration range recited in the claims. However, such obvious to try rejections have been consistently disapproved by the CAFC, see, for example, In re Fine, 5 USPQ 2d 1596, 1599 (Fed. Cir. 1988); In re Geiger, 2 USPQ 1276, 1278 (Fed. Cir. 1987); and In re Goodwin, 198 USPQ 1 (CCPA 1978).

The attention of the Examiner is also directed to new independent claims 33-35 which correspond to present claims 23, 25 and 27 where each of the new claims is limited to the oxygen concentration being not higher than $1x10^{19}$ atoms/cm^3. Nakagawa teaches that the amount of oxygen atoms may be 0.03-5 atomic% in column 3. However, 0.03 atomic% corresponds to $1.5x10^{19}$. Accordingly, new claims 33-35 are even further distinguished with respect to the Nakagawa reference.

Reference is now made to the crystallinity range recited in the claims using the different recitations of claims 23, 25 and 27 where, for example, in

claim 23 the crystallinity of the semiconductor layer is defined in terms of it exhibiting a Raman shift at a wavenumber of 512 cm-1 or higher. The significance of this definition and the definitions of claims 25 and 27 are extensively discussed in the Amendment of August 8, 1994.

Having established above that the Nakagawa reference fails to teach in the sense required by 35 U.S.C. 103 the upper limit on the impurity concentration range of $5x10^{19}$ atoms/cm^3 as recited in claims 23, 25 and 27, the following remarks are now made with respect to the crystallinity of the polysilicon layer of Nakagawa. First it is noted in Item 4 of the Office Action that it is stated that "the channel layer is later crystallized by heating the substrate. However, applicant is unable to find such a teaching in Nakagawa. Rather, Nakagawa teaches formation of the polysilicon layer simply by CVD. There is no subsequent crystallization thereof by heat or otherwise.

Moreover, it is urged in the Office Action that the Raman shift numbers recited in the claims are all obtained by changing the amount of oxygen, nitrogen or carbon which as commonly known in the art results in change of crystallization of the amorphous silicon and formation of larger grain sizes. However, there is no cited reference which supports this statement. As stated in the specification at page 5, second full paragraph, the claimed Raman shift numbers obtained by crystallizing an amorphous semiconductor layer <u>with melting</u> using a laser light. It is applicant's invention that the claimed impurity concentrations facilitate the formation of a crystalline silicon having the claimed Raman shift numbers.

It is also apparently contended in the Office Action that since Nakagawa discloses an average grain size of 200Å or more to enhance carrier mobility, see column 4, lines 17-29 that the foregoing range on the crystal size is

equivalent to stating that the crystallinity of the Nakagawa semiconductor falls within the ranges recited in claims 23, 25 and 27. However, the Raman shift number does not directly relate to the grain size. Rather, the Raman shift number is directly related to the lattice distortion. However, FWHM does relate to grain size. Generally, the larger the grain size, the smaller the FWHM. In any event, it cannot be determined from Nakagawa's teachings whether the Nakagawa semiconductor inherently possesses the claimed degree of crystallinity.

Finally, it should be emphasized that the claims of the subject application are characterized by the combined features of (a) the presence of carbon, nitrogen or oxygen in an amount less than a predetermined maximum and (b) the presence of a predetermined degree of crystallinity whereby electron mobilities in the non-single crystalline channel semiconductor layer can approximate those obtainable with a single crystalline silicon semiconductor layer, see page 4 of the August 8, 1994 Amendment. It is the interrelationship of the features (a) and (b) which permits a semiconductor layer having the high electron mobilities of the present invention to be easily fabricated. That is, by keeping the impurity levels below the predetermined maximum recited in the claims, crystallinities in the range defined by the Raman shifts in the claims can be readily obtained whereby the good electron mobilities can thus be achieved. As discussed above there is a complete failure on the part of Nakagawa to realize that the impurity concentration must be kept below the foregoing predetermined maximum in order to readily achieve semiconductor layers having high electron mobilities. In fact, Nakagawa teaches away from the present invention inasmuch as his 5 atomic% upper limit is substantially greater than the 10x19 atoms/cm^3 upper limit of the

claims.

Referring to section 5 of the Office Action, it is urged claims 29-31 are product-by-process claims and thus, in order for such claims to distinguish over Nakagawa, it must be demonstrated that they structurally distinguish over this reference. Since these claims are dependent on claims 23, 25 and 27 and since claims 23, 25, and 27 do structurally distinguish over Nakagawa for the reasons stated above, it is urged dependent claims 29-31 are also patentably distinguishable over Nakagawa.

Referring to section 6 of the Office Action, claims 23-31 are rejected under the doctrine of obviousness-type double patenting over the claims of U.S. Patent No. 5,313,076. However, the claims of '076 are directed to an invention different from that of the claims of the subject application. Thus, referring to claims 1, 5 and 9 of '076, all of these independent claims require that laser irradiate the semiconductor film without melting the semiconductor film to make the degree of crystallinity of the semiconductor film higher. However, as illustrated in Appendices I, II and III of the August 8, 1994 amendment, the invention of the subject application is characterized in that the semiconductor layer is formed by melting and crystallizing the semiconductor. Hence, in this first respect the claims of '076 differ from those of the subject application.

Moreover, the crystallinity of the claims of the subject application are characterized, as discussed above, in that the semiconductor layer exhibits a Raman shift at a wavenumber of $512cm^{-1}$ or higher while the crystallinity recited in claims 2, 6, and 15 of '076 is such that the semiconductor exhibits a Raman peak (shift) of $517cm^{-1}$ or less. Hence, although there may be a relatively small overlap in the Raman shift ranges recited in the claims of '076

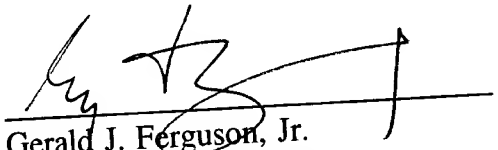
and those of the subject application, it is clear the subject application is directed to a semiconductor entirely different from that of '076 and thus the remarks above with respect to Nakagawa regarding an "obvious to try" rejection also applies to the double patenting rejection with respect to '076. Hence, it is urged the claims of the subject application are patentably distinguishable with respect to the claims of '076.

The Examiner's attention is also directed to new claim 32 which is comparable to claim 1 of the '076 patent in claim format - that is, product-by-process. It is submitted that this type of claim is allowable for the same reasons that claim 1 of '076 was allowed.

Referring to section 8 of the Office Action, claims 5-14 have been cancelled without prejudice as requested by the Examiner.

In view of the foregoing amendments and remarks, it is urged this case is now in condition for allowance and a notice to that effect is requested.

Respectfully submitted,



Gerald J. Ferguson, Jr.
Registration No. 23,016

Sixbey, Friedman, Leedom & Ferguson, P.C.
2010 Corporate Ridge, Suite 600
McLean, Virginia 22102
(703) 790-9110